

WHAT IS CLAIMED IS:

Sub A1
1. A method for forming an interlayer insulating film comprising the steps of:

5 forming a film containing B (boron), C (carbon) and H₂O on a substrate (by plasma enhanced chemical vapor deposition using a source gas containing an Si-C-O-H compound, an oxidative gas and a compound containing B (boron); and

10 annealing said film, releasing C (carbon) and H₂O contained in said film from said film, and thereby forming said film into a porous SiO₂ film containing B (boron).

2. A method according to claim 1, wherein said oxidative gas is any one of O₂, O₃ and H₂O.

3. A method according to claim 1, wherein an inert gas is added to said source gas.

15 4. A method according to claim 3, wherein said inert gas is Ar.

Sub A2
5. A method according to claim 1, wherein said annealing is performed by O (oxygen) plasma.

20 6. A method according to claim 1, wherein a temperature of said substrate for said annealing is higher than the temperature for forming said film containing B (boron), C (carbon) and OH.

7. A method according to claim 1, wherein said Si-C-O-H compound is one selected from the group consisting of
25 compounds designated by a general formula Si(OR)_nH_{4-n} (R=CH₃ or C₂H₅, n=1 to 3).

8. A method according to claim 1, wherein an

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underlying insulating film is formed on said substrate, and said porous SiO₂ film is formed on said underlying insulating film.

9. A method according to claim 1, wherein said porous SiO₂ film is formed, and then said porous SiO₂ film is subjected to H (hydrogen) plasma treatment.

10. A method according to claim 1, further comprising the steps of:

forming said interlayer insulating film on said substrate and then forming a damascene trench in said interlayer insulating film;

forming a side wall insulating film on sides of said damascene trench;

embedding a metal film in said damascene trench; and forming a barrier metal layer on said metal film.

11. A method according to claim 10, wherein said side wall insulating film is formed by the steps of:

forming said damascene trench and then forming a first insulating film on said interlayer insulating film, on the sides of said damascene trench and on a bottom of said damascene trench; and

anisotropically etching said first insulating film to such an extent that said first insulating film formed on the sides of said damascene trench remains and said first insulating film formed on the bottom of said damascene trench is removed.

12. A method according to claim 1, further comprising

forming said interlayer insulating film on said substrate and then forming a damascene trench in said interlayer insulating film;

embedding a metal film in said damascene trench; and
forming an anti-oxidizing film on said metal film.

14. A method for forming an interlayer insulating film comprising:

a second step of annealing said film, releasing the C-O-H polymer contained in said film from said film, and thereby forming a porous SiO₂ film on said substrate.

16. A method according to claim 14, wherein O_2 is added to said source gas.

18. A method according to claim 17, wherein said inert

gas is Ar.

19. A method according to claim 14, wherein said annealing is performed by O (oxygen) plasma.

20. A method according to claim 14, wherein a
5 temperature of said substrate for said annealing is higher than the temperature for forming said film containing the C-O-H polymer.

21. A method according to claim 14, wherein said Si-C-O-H compound is one selected from the group consisting of
10 compounds designated by a general formula $\text{Si}(\text{OR})_n\text{H}_{4-n}$ ($\text{R}=\text{CH}_3$ or C_2H_5 , $n=1$ to 3).

22. A method according to claim 14, wherein an
underlying insulating film is formed on said substrate, and said porous SiO_2 film is formed on said underlying
15 insulating film.

23. A method according to claim 14, wherein said porous SiO_2 film is formed, and then said porous SiO_2 film is subjected to H (hydrogen) plasma treatment.

24. A method according to claim 14, further comprising
20 the steps of:

forming said interlayer insulating film on said substrate and then forming a damascene trench in said interlayer insulating film;

forming a side wall insulating film on sides of said
25 damascene trench;

embedding a metal film in said damascene trench; and

forming a barrier metal layer on said metal film.

25. A method according to claim 24, wherein said side wall insulating film is formed by the steps of:

forming said damascene trench and then forming a first insulating film on said interlayer insulating film, on the sides of said damascene trench and on a bottom of said damascene trench; and

anisotropically etching said first insulating film to such an extent that said first insulating film formed on the sides of said damascene trench remains and said first insulating film formed on the bottom of said damascene trench is removed.

26. A method according to claim 14, further comprising the steps of:

forming said interlayer insulating film on said substrate and then forming a damascene trench in said interlayer insulating film;

forming a barrier metal layer on the sides and bottom of said damascene trench;

embedding a metal film in said damascene trench; and forming an anti-oxidizing film on said metal film.

27. A method according to claim 14, wherein said interlayer insulating film is formed, and then a cover insulating film is formed on said interlayer insulating film.

28. An apparatus for forming an interlayer insulating film comprising:

a chamber for forming a film;

pipes for supplying a source gas to said chamber;

flow rate control means attached to said pipes, for controlling a flow rate of said source gas;

high-frequency power generating means for applying a high-frequency power to said chamber;

5 switching means for inputting or shutting off said high-frequency power applied to said chamber; and

control means for controlling said flow rate control means and said switching means.

29. An apparatus according to claim 28, wherein said
10 control means controls said flow rate control means, thereby periodically changing the flow rate of said source gas.

30. An apparatus according to claim 28, wherein said
control means controls said switching means, thereby
periodically changing said high-frequency power applied to
15 said chamber.

31. An apparatus according to claim 28, wherein said
control means controls said flow rate control means and said
switching means, thereby changing the flow rate of said
source gas and said high-frequency power applied to said
20 chamber in the same cycle and in the same phase.

32. An apparatus according to claim 28, wherein said
source gas is one selected from the group consisting of a
gas mixture of an Si-C-O-H compound and H₂; a gas mixture of
an Si-C-O-H compound, H₂ and O₂; a gas mixture of an Si-C-O-
25 H compound, H₂ and Ar; a gas mixture of an Si-C-O-H compound,
H₂ and He; a gas mixture of an Si-C-O-H compound, H₂, O₂ and
Ar; a gas mixture of an Si-C-O-H compound, H₂, O₂ and He; a

gas mixture of an Si-C-O-H compound and H₂O; a gas mixture of an Si-C-O-H compound, H₂O and Ar; and a gas mixture of an Si-C-O-H compound, H₂O and He.

5 33. A semiconductor device comprising an interlayer insulating film formed by a method for forming an interlayer insulating film according to claim 1.

34. A semiconductor device comprising an interlayer insulating film formed by a method for forming an interlayer insulating film according to claim 3.

10 35. A semiconductor device comprising an interlayer insulating film formed by a method for forming an interlayer insulating film according to claim 4.

15 36. A semiconductor device comprising an interlayer insulating film formed by a semiconductor manufacturing apparatus according to claim 28.

37. A semiconductor device comprising an interlayer insulating film formed by a semiconductor manufacturing apparatus according to claim 29.

20 38. A semiconductor device comprising an interlayer insulating film formed by a semiconductor manufacturing apparatus according to claim 30.

39. A semiconductor device comprising an interlayer insulating film formed by a semiconductor manufacturing apparatus according to claim 31.